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A model for calculation of growth and feed intake in broiler chickens on the basis of feed composition and genetic features of broilers.

Bernard Carré

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Abstract The model shown in the current publication is based on an equation system developed in a previous publication (Carré et al., 2015). An equation (D) describing protein deposition as a function of protein intake is added to this previous system, in order to obtain a complete description of growth and feed intake depending on feed composition and genetic features of broilers. A calculation is conducted for lean and fat lines with various dietary protein contents. Lean and fat lines are distinguished through the equation expressing lipid deposition as a function of [protein/energy] ratio and protein efficiency, and through the equation (D). The model provides results that are typical of differences between lean and fat lines, with a higher dietary protein recommendation for lean than for fat line, lower feed conversion ratios (FCR) in lean than in fat line, and higher protein efficiencies in lean than in fat line.

Key words: poultry, chicken, avian, growth, energy, ME, protein, fat, model, feed intake

Introduction

It was previously shown that the feed intake of broilers could be calculated from the knowledge of feed composition (metabolizable energy (ME) and crude protein (CP) contents) and body weights (BW) at beginning and end of a growth period (Carré et al., 2015). Thus, BW and growth data were required to calculate feed intake. It is proposed in the current publication to improve this approach by introducing an equation allowing growth to be calculated.

Materials and methods

Calculations

Equations are the 6 equations E1 to E6 shown in a previous publication (Carré et al., 2015), with Equation E2 being replaced by Equation R5 (Carré et al., 2015). To this system is added the following equation “(D)” describing the daily protein deposition as a function of protein intake.
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with an asymptote “a” and an ascending line “L” having a slope value “P” and an intercept value “E” (Figure 1):

(D): \( Y = a - b e^{-e A X} \)

With: \( Y = \) daily protein deposition (g)
\( X = \) daily protein intake (g)

The slope \( P \) is assumed to depend on the amino acid composition of dietary protein and on the genetic feature of broilers. It is also assumed that \( P \) is higher in a lean line than in a fat line as expected from a previous study (Leclercq and Guy, 1991). \( E \) represents the endogenous protein losses with the energy requirement being met.

Table 1. Equations of the nutrition model for broilers. Examples of calculations are shown in Table 2.

<table>
<thead>
<tr>
<th>Equation</th>
<th>Description</th>
<th>Example Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( A = ) final body weight (kg)</td>
<td>( = 0.7 + B / 1000 \times 14 )</td>
<td></td>
</tr>
<tr>
<td>( B = ) daily weight gain (g)</td>
<td>( = I / H )</td>
<td></td>
</tr>
<tr>
<td>( C = 0.7^{0.634} + A^{0.634} / 2 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( D = 0.7^{0.418} + A^{0.418} / 2 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( E = ) daily feed intake (DFI; g)</td>
<td>(proposed value)</td>
<td></td>
</tr>
<tr>
<td>( F = ) fat content of body weight gain (FCG; g/g)</td>
<td>(proposed value)</td>
<td></td>
</tr>
<tr>
<td>( G = ) daily protein deposition (DPD; g)</td>
<td>(proposed value)</td>
<td></td>
</tr>
<tr>
<td>( H = ) protein content of body weight gain (PCG; g/g)</td>
<td>( = (0.179 + 0.00169 \times 28) (1-F) )</td>
<td></td>
</tr>
<tr>
<td>( I = ) DPD (calculated value) for lean line</td>
<td>( = 13 - 11.51 e^{(0.100 e^{(0.145 J)}} )</td>
<td></td>
</tr>
<tr>
<td>( I = ) DPD (calculated value) for fat line</td>
<td>( = 13 - 11.51 e^{(0.100 e^{(0.131 J)}} )</td>
<td></td>
</tr>
<tr>
<td>( J = ) daily protein intake (DPI; g)</td>
<td>( = E \times 20.00 / 100 )</td>
<td></td>
</tr>
<tr>
<td>( K = ) apparent metabolizable energy value of diet (AME; MJ/kg)</td>
<td>( = 13.01 + 1000 (0.0344 B \times H / 6.25 / E) )</td>
<td></td>
</tr>
<tr>
<td>( L = ) daily intake of AME (MEI; MJ)</td>
<td>( = 0.68 C + 0.03918 \times 1.116 B \times F + 0.02369 \times 1.388 B \times H )</td>
<td></td>
</tr>
<tr>
<td>( M = ) protein efficiency (PE; g/g)</td>
<td>( = I / J )</td>
<td></td>
</tr>
<tr>
<td>( N = ) daily feed intake (DFI) (calculated value)</td>
<td>( = 1000 L / K )</td>
<td></td>
</tr>
<tr>
<td>( O = ) fat content of body weight gain (FCG) (calculated value) for lean line</td>
<td>( = 12.99 (0.137 D + 0.025) e^{(-1.082 \times 20.00 / 13.01 - 2.09 M)} )</td>
<td></td>
</tr>
<tr>
<td>( O = ) fat content of body weight gain (FCG) (calculated value) for fat line</td>
<td>( = 15.20 (0.137 D + 0.025) e^{(-1.082 \times 20.00 / 13.01 - 2.09 M)} )</td>
<td></td>
</tr>
<tr>
<td>( P = ) feed conversion ratio (FCR; g/g)</td>
<td>( = N / B )</td>
<td></td>
</tr>
<tr>
<td>( Q = (1 - E / N)^2 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( R = (1 - F / O)^2 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( S = (1 - G / I)^2 )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Examples of calculations of broiler growth performance from the feed composition (energy value and crude protein) and the protein and lipid deposition curve responses assumed from broiler genetics (maximum growth potential and fatness) and amino acid composition of dietary proteins (details of equations are shown in Table 1).

<table>
<thead>
<tr>
<th>Bases</th>
<th>Calculated values</th>
<th>Proposed values</th>
<th>Calculated values</th>
<th>Defined values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Final BW (kg)</td>
<td>DG (g)</td>
<td>Mean BW*1000 kg</td>
<td>AME (MJ/kg)</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>L</td>
</tr>
<tr>
<td>L-14</td>
<td>1.208</td>
<td>36.3</td>
<td>0.962</td>
<td>0.000</td>
</tr>
<tr>
<td>L-15</td>
<td>1.292</td>
<td>42.3</td>
<td>0.987</td>
<td>0.000</td>
</tr>
<tr>
<td>L-18</td>
<td>1.389</td>
<td>49.2</td>
<td>1.015</td>
<td>0.000</td>
</tr>
<tr>
<td>L-20</td>
<td>1.477</td>
<td>55.5</td>
<td>1.039</td>
<td>0.000</td>
</tr>
<tr>
<td>L-22</td>
<td>1.533</td>
<td>59.5</td>
<td>1.054</td>
<td>0.000</td>
</tr>
<tr>
<td>L-24</td>
<td>1.558</td>
<td>61.3</td>
<td>1.061</td>
<td>0.000</td>
</tr>
<tr>
<td>L-26</td>
<td>1.565</td>
<td>61.8</td>
<td>1.063</td>
<td>0.000</td>
</tr>
<tr>
<td>F-14</td>
<td>1.392</td>
<td>49.5</td>
<td>1.016</td>
<td>0.000</td>
</tr>
<tr>
<td>F-16</td>
<td>1.453</td>
<td>53.8</td>
<td>1.032</td>
<td>0.000</td>
</tr>
<tr>
<td>F-18</td>
<td>1.513</td>
<td>58.1</td>
<td>1.049</td>
<td>0.000</td>
</tr>
<tr>
<td>F-20</td>
<td>1.557</td>
<td>61.2</td>
<td>1.061</td>
<td>0.000</td>
</tr>
<tr>
<td>F-22</td>
<td>1.582</td>
<td>63.0</td>
<td>1.067</td>
<td>0.000</td>
</tr>
<tr>
<td>F-24</td>
<td>1.591</td>
<td>63.6</td>
<td>1.070</td>
<td>0.000</td>
</tr>
<tr>
<td>F-26</td>
<td>1.590</td>
<td>63.6</td>
<td>1.070</td>
<td>0.000</td>
</tr>
</tbody>
</table>

1 Initial BW is 0.7 kg. Mean age of broilers for growth period is 28 days. Duration of growth period is 14 days. AMEn value of diets is 13.01 MJ/kg. “L-14” and “F-14” mean broilers from lean and fat lines, respectively, fed a diet containing 14% crude protein (N×6.25).
2 Values of E, F and G are found in order to obtain zero for Q, R and S, using the Excel solver system.
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For the calculations shown in the current study, a common asymptotic “a” value of 13g/day was attributed to each line. P values of 0.59 and 0.53 were attributed to lean and fat lines, respectively, and a constant E value of 0.6 g/day was attributed to each line and each dietary protein concentration, which resulted in the fitted equations shown for “I” in Table 1. Fitting of these equations were obtained by fixing the Y and X values at Y = 0.95a; 0.75a; 0.62a; 0.50a, as shown in Figure 1.

For the equations expressing the lipid content of weight gain shown for “O” in Table 1, the α values (Carré and Méda, 2015) of 12.99 and 15.20 were attributed to lean and fat lines, respectively, in agreement with the α values found for males from experimental lean and fat lines (Carré and Méda, 2015).

Results of calculations are shown in Table 2 for lean and fat lines, with dietary protein contents varying from 14 to 26%. Figure 2 is an illustration of Table 2.

**Results and discussion**

Results of calculations are illustrated in Figure 2. According to the growth curves shown by the model, the lean line requires a higher dietary protein content than the fat line for expressing the growth potential (Figure 2). The model calculation provides feed conversion ratios (FCR) that are lower in lean than in fat line (Figure 2). According to the model, protein efficiencies (PE) are higher in lean than in fat line (Figure 2). All these results are in agreement with experimental studies comparing lean and fat lines (Leclercq and Guy, 1991; Carré and Méda, 2015), which shows the reliability of the model.

Distinguishing lean and fat lines is performed in the model through two equations using a specific

![Figure 2: curves obtained from the model shown in Table 1 for lean - and fat -- lines](image-url)
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coefficient for each line. One of these equations concerns fat deposition (“O” in Table 1) with a higher fat deposition in the fat line; the other equation concerns protein deposition (“I” in Table 1) with a better protein efficiency in the lean line. When one of these equations does not express any difference between lines using the same coefficients for both lines, the model fails in expressing all the typical differences between the lean and fat lines. Thus, both equations are needed to express all the differences between lean and fat lines. Considering the process of fat deposition, the equation of fat deposition (“O” in Table 1) expresses the “pull” phenomenon, while the equation of protein deposition (“I” in Table 1) expresses the “push” phenomenon. Thus, it is probably logical that the model works only if the whole process is expressed (the “push” and “pull”).

It is stated above that the slope “P” depends on the genetic feature of broilers and on the amino acid composition of dietary proteins. Knowledge about the relationship between “P” and this amino acid composition represents future developments of this model for computing dietary amino acid recommendations.

References
